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USSR Report

ENERGY

(FOUO 2/82)



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ELECTRIC POWER

UDC[621.311.25:621.039].004

PROGRESS AT KOLA AES IN 10TH FIVE-YEAR PLAN DESCRIBED

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 81 pp 2-5

[Article by engineers A. P. Volkov and B. A. Trofimov: "The Kola AES in the 10th Five-Year Plan"]

[Text] The Kola nuclear electric power station, a pioneer of the nuclear power industry, has been included among the operating stations for eight years. During this period, the station's collective accumulated a great deal of experience in mastering the output of the units which have been commissioned and the prototype power equipment. The collective has gained experience in training operational personnel and has occupied a leading position among the progressive collectives in the industry.

Particularly significant successes were achieved during the years of the 10th Five-Year Plan. In comparison with 1975, the generation of electric power from the same power units increased by a factor of 2.7, the specific consumption of conventional fuel was reduced by 23 g and the efficiency increased by 2.4 percent.

The qualitative improvement in the technical and economic indicators basically came about due to the increase in the installed capacity utilization factor, which in 1980 was 0.935 as opposed to the design figure of 0.8. Over the course of the five-year plan, the cost per kWh of electric power was reduced by 62.1 percent. The cost is 0.633 kopecks per kWh as opposed to the design figure of 0.717.

The expenditure of electricity for auxiliary power was reduced by 0.03 percent last year, which made it possible to supply an additional 2.2 million kWh of electric power to the consumer. Over the five-year period, we conserved 53,795 t of conventional fuel and 30.4 million kWh of electric power.

In the 10th Five-Year Plan we implemented an important program for the construction of housing and the commissioning of facilities for trade, health care, culture and education. Living conditions for station workers were improved, and their professional, general educational and cultural levels rose. The collective's successes were given a high appraisal by the party, the government and the administration of the USSR Ministry of Power and Electrification.

According to the results of All-Union socialist competition, the Kola AES collective in 1978 was awarded the challenge Red Banner of the USSR Central Committee, the

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USSR Council of Ministers, the All-Union Central Trade-Union Council and the Komsomol Central Committee, and the award was recorded on the All-Union Board of Honor at the Exhibition of Achievements of the National Economy of the USSR. The collective was 12 times awarded the challenge Red Banner of the USSR Ministry of Power and Electrification and the Central Committee of the industry trade union.

A group of workers at the Kola AES were presented with high government awards, among whom were: loading-machine operator S. M. Loginov--Order of Lenin; senior reactor-compartment operator Yu. I. Begesh--Order of the Red Banner of Labor; centralized repair shop supervisor L. B. Studerikin--Order of Friendship of Peoples, senior turbine machinist V. A. Novikov--Order of the "Badge of Honor"; decontamination specialist A. M. Pushkina--medal "For Labor Valor"; flaw-detector operator N. P. Morokko--medal "For Labor Excellence".

Labor productivity in the years of the 10th Five-Year Plan rose by a factor of 2.5 with a 39 percent average increase in salaries. The relative number of administrative and technical personnel has been reduced by 16.3 percent, while personnel turnover has been reduced by a factor of 1.5 and in 1980 amounted to 3.3 percent.

The achievement of high technical and economic indicators is a result of the collective's persistent and systematic work, the active utilization of the achievements of science and technology and progressive experience. In 1980 alone we implemented organizational and technical measures having an economic impact of 1.5 million rubles, rationalization suggestions having an economic impact of 595,000 rubles and inventions with an impact of 554,000 rubles. During the 10th Five-Year Plan, the overall impact of measures directed at increasing technical progress was 15.3 million rubles.

We implemented a system of operations to improve the water-chemical regime: we have developed and introduced a new regime which makes it possible to improve the corrosion-protection of the equipment in the stagnant-water regime; we have developed and introduced hydraulic processing of the coolant, which makes it possible to extend the duration of the fuel cycles by 15 effective days due to the removal of corrosive precipitates from the fuel rods; we have developed and introduced a new operational water-chemical regime which has also improved considerably the radiation state of the equipment in the first circuit.

Work is constantly under way at the AES to improve operational maneuverability and maintenance. Together with workers from the All-Union Institute of Heat Engineering imeni F. E. Dzerzhinskiy, we have conducted experimental research and introduced an operational regime which makes it possible to stop individual operational loops for repairs. This makes it possible to generate, on the average, an additional 120 million kWh of electric power annually.

The renovation of the seal connections on the high-pressure cylinder and the change-over from nozzle steam distribution to valved distribution has made it possible to increase the reliability and economy of the turbine units and to switch from a three-year to a four-year maintenance cycle. The automation of control over the water-chemical regime in the second circuit made it possible to service newly commissioned power units without increasing the number of laboratory chemists. Work is being done to create an automated system of production control (ASU AES). A computer center will be commissioned in 1981.

One of the major directions of the collective's activities is the protection of the environment. During the 10th Five-Year Plan, we introduced more than 100 measures regarding the protection of the environment and the efficient utilization of natural resources at a cost of 5.27 million rubles. We built and introduced purification facilities for oil and grease-fouled discharges as well as other purification facilities for the settlement.

A considerable amount of work is being done at the AES by members of the scientific and technical society, a council of junior specialists, the All-Union Rationalizer Society and the "Znaniye" society. The economic impact from just the introduction of personal creative plans on the part of Scientific and Technical Society members amounted to 265,000 rubles in 1980. The plan of Yu. N. Pytkin, senior engineer in the physics laboratory, was submitted for an honorary certificate from the All-Union Scientific and Technical Society and the Central Administration of the Scientific and Technical Society of the Power and Electrification Industry.

The overall economic impact from the introduction of rationalization proposals and inventions amounted to 10.3 million rubles during the five-year plan. The All-Union Society of Inventors and Efficiency Experts [VOIR] was awarded an honorary certificate from the VOIR's Central Council "For Early Creation of a Savings Fund in the 10th Five-Year Plan."

Based on the results of socialist competition, among the best rationalizers were: N. V. Ovdin--machinist on the modular control panel and author of two rationalization proposals with an overall economic impact of 43,000 rubles; V. P. Chernyy--electric welder in the TPK shop [expansion not provided] and author of six rationalization proposals to increase the reliability and operational efficiency of the equipment; A. A. Matveyev--senior engineer in the physics laboratory and coauthor of the invention "A Method for Increasing Fuel-Cycle Duration" (with an economic impact of more than 600,000 rubles) and two rationalization proposals for operational control over the burn-up of fuel.

The work team in the metals and welding laboratory was recognized as the best creative team. The team is composed of senior engineer Yu. A. Rychkov, technician N. P. Morokko and flaw-detector operator V. V. Klimov. They are all authors of four rationalization proposals to improve metal monitoring and are the creators of devices and equipment for remote monitoring of metals in the equipment.

Deputy chief engineer V. I. Pashkevich was submitted for award of the title "Honored Inventor of the RSFSR."

At the Kola AES, 46 studies were carried out in accordance with contracts for creative cooperation with scientific research operations.

The next scheduled generating unit has been built. It began generating power on 24 March 1981. This is a great victory for the collectives of construction and installation, start-up and adjustment, scientific, design and planning organizations as well as the operational personnel at the Kola AES.

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In connection with this, we should note that the design of the new power unit, developed by the Leningrad branch of Teploelektroproyekt, is qualitatively different from the designs for units previously put into operation. Characteristic of this new unit is the application of a modular system for the production equipment and standard structural elements of precast reinforced concrete; the utilization of 450 newly developed pieces of equipment which, in the opinion of the design's authors, should increase the reliability and operational economy of similar power units, standardize the equipment and structural elements and reduce construction times.

The design for the third generating unit differs in its more extensive utilization of automated production-process equipment. An automated control system for the unit with new-generation data-processing computers is being used as the basis of the system.

This automated control system includes a system of automatic regulation using automatic electronic regulators, remote control devices and the full scope of operational protection equipment as well as data-processing and control computers. This system has made it possible to eliminate cumbersome control panels, since the machine periodically "runs through" the sensors for all parameters and signals when there is a malfunction in any of them. While doing so, the machine automatically records the time, the magnitude of the error and the number of the parameter. In addition, the machine records a certain number of values using the basic recording devices. This makes it possible to free the personnel from watching over a great many instruments and recording their readings.

The data-processing computer also performs as an "advisor" for the operator. In subsequent stages, the machine will also be charged with generating-unit control functions.

The power-equipment builders also approached the delivery of equipment in a new way. The new equipment differed in its high-quality manufacture, stemming from the application of improved raw materials, better technological effectiveness and intensified monitoring of manufacturing quality at its various stages.

There is no doubt that the operations personnel at the Kola AES contributed much to putting the station into operation. They worked hand-in-hand with the builders and installation workers, solving the problems that arose and helping to carry out the work.

The successful erection of the new power units at the Kola AES has also been possible in recent years because this urgent All-Union Komsomol construction project is at the center of attention of the Komsomol and party organizations. In a persistent and effective manner, they helped to solve the most complex issues regarding the supply of materials and equipment and, most important, qualified construction and installation personnel.

The start-up of the power unit at the Kola AES confirmed the tradition of advancing development of the electric-power industry on the Kola Peninsula. This makes it possible to solve problems regarding the further development of industry, transport, agriculture, the electrification of home life and service spheres. It will also improve the fuel-and-power balance of our country's northwest sector.

Even more complex tasks face the collective in the current five-year plan. Chief among them are:

develop the design output of the third power unit, commissioned during the first quarter of 1981;

complete the construction and insure the start-up of the fourth power unit in 1983;

insure reliable, economical and steady operation of all Kola AES power units in the power system.

The workers, engineering and technical personnel and staff of the Kola AES are filled with resolve to carry out these tasks successfully. We have all the necessary conditions and resources for this.

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ELECTRIC POWER

SOVIETS PUBLISH MAP SHOWING ELECTRIC POWER STATIONS, NETWORKS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 6, Jun 81 pp 70-71

/Article by P.G. Grudinskiy, professor, council of senior power engineers: "Map 'Lenin's Path for the Electrification of the Soviet Union'"7 *

/Text/ The Soviet Union has celebrated the 60th anniversary of Lenin's electrification plan - the famous GOELRO.

Prior to this date the Main Administration of Geodesy and Cartography of the USSR Council of Ministers published a multi-color map of the Soviet Union showing the most important electric power stations and networks. The map is rightly called "Lenin's Path for the Electrification of the Soviet Union."

V. I. Lenin was keenly interested in maps that showed electrification. In his comments concerning the publication of an atlas Lenin demanded that it contain a map showing electrification. ** In a letter to G. M. Krzhizhanovskiy that dealt with preparation of documents to acquaint members of the 3rd Comintern Congress with the electrification plan he wrote: "there must be included (in the lobbies of the congress) 1) a map showing electrification with a brief text in three languages; 2) also, regional maps;... 4) and a map of the more important local, small and new electric power stations. And there must be a brief (16 - 24 pages) brochure in three languages and an abstract on the "electrification plan." ***

* Scientific advisors G. A. Illarionov and V. Yu. Steklov. Text by V. Yu. Steklov. Moscow. Main Administration of Geodesy and Cartography of the USSR Council of Ministers, 1980

** V. I. Lenin, Complete Works, Vol 52, pp 163, 165.

*** V. I. Lenin, Complete Works, Vol 52, pp 250-251.

For several years the Main Administration of Geodesy and Cartography has been performing a valuable service by publishing maps showing electrification.

This new map reflects the status of electrification in the USSR as of 1980 and its development in the near future. It includes diagrams which show the growth rates of the electric power industry, the consumption of electric power by the leading sectors of the national economy, the electrification of railroads, and so forth. A diagram showing the GOELRO electrification plan occupies a special place in this publication.

The map shows the period or year that the power station was built, what kind of power station it is (TES, GES, AES), which power stations have a rated capacity greater than one million kW, and what electric power stations are being built and the high voltage electric power transmission lines that are being erected. It also makes note of the basic trends in Soviet power engineering - the powerful hydroelectric power stations in Siberia, the atomic electric power stations in the west and in the central regions of the Soviet Union. It also shows the mainline lines for intersystem ties and the routes of the 1,150 kV AC and the 1,500 kV DC power lines.

The electrification map clearly reflects the status and future development of the atomic power industry.

A quick glance at the map enables one to grasp the enormity of what has been accomplished by the Soviet Union by pursuing Lenin's path from the GOELRO plan to the present.

The Unified Power System has encompassed the entire Soviet Union, covering the USSR with a dense network. The system's powerful electric power stations are spread throughout the Soviet Union. Electric power mainlines are being built which will be linked with power systems of Asia and the Far East into the National Unified Electric Power System.

In 1978 the National Unified Electric Power System's electric power stations produced 75 percent of all power produced in the Soviet Union. At the end of the 10th Five-Year Plan this indicator reached 88 percent; and by the end of the 11th Five-Year Plan it must exceed 95 percent. We are close to realizing V. I. Lenin's great idea on the creation of the National Unified Electric Power System, which has been supported by directives from the 23rd, 24th and 25th party congresses.

The rich information of the map is augmented by the text in a separate brochure, which was written by V. Yu. Steklov, who is known for his publications on the history of electrification. The brochure provides a brief review of the development of Leninist ideas on electrification. It provides data on the more important stages in the construction of electric power stations and networks and their joining together into electric power systems. Emphasis is given to the dynamics of developing the electric power industry and to the leading principles for the key periods. There is an outline of the principles of Lenin's teachings on electrification and their effect in the basic stages of creating the National Unified Electric Power System.

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The diagram and map of the development of the electric power industry and the explanatory information make it possible to come up with a complete picture of Soviet electrification.

The map and the explanatory brochure are especially useful for Soviet propaganda agitators, students, technicians and engineers at power enterprises. It would be useful to display this map in each power industry organization and in each of their Red Corners for the education and training of Soviet power specialists and engineers.

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ELECTRIC POWER

UTILIZATION OF NUCLEAR FUEL

Moscow NOVovorONEZHskaya ATOMNAYA ELEKTROSTANTSIIYA IMENI 50-LETIIYA
SSSR - FLAGMAN SOVETSKOY YADERNOY ENERGETIKI in Russian 1981 pp.26-36

/Translation of section entitled "Utilization of Nuclear Fuel" from
book: "Novovoronezh Atomic Electric Power Station imeni 50 Years of
the Soviet Union - Flagman of the Soviet Atomic Power Industry", by
V. K. Sedov/

/Text/ The core of a reactor is an object of constant observations
and research directed at increasing the relative intensity of the fuel
elements, equalizing the irregularities in the radius and height of
the core and increasing the depth of the burning of the nuclear fuel.
As a result the thermal capacity of the core is increased from 760 MW
in the first power unit to 1,375 MW in the third and fourth power units
without changing the size of the reactor's core. This became possible
primarily by equalizing the field of the release of energy and adopt-
ing a liquid regulation of reactivity using boric acid. The surface
of heat exchange of the core has been increased in power units 2, 3
and 4. In each fuel assembly there are 126 fuel elements [tvel] with
a diameter of 9.1 mm instead of 90 fuel elements with a diameter of
10.2 mm, which are used in the first power unit. The irregularity
coefficient of the release of energy for the radius of the core is re-
duced from 1.8 to 1.25-1.35. The duration of the operating period of
the reactor is increased from 210 to 280-320 effective 24-hour periods,
which with consideration of the coefficient of use of the rated capa-
city and duration of the downtime of the power unit for reloading and
repair makes it possible to replace the nuclear fuel once a year.

Over the long period of time that the Novovoronezh AES has been in
operation a significant amount of experience has been amassed in the
use of nuclear fuel in reactors.

Nuclear fuel is reloaded once a year in all power units. The yearly
planned preventive maintenance of the equipment is done at the same
time that the reactor is refueled. At the AES they have successfully
assimilated the practice of refueling with the unloading of the nu-
clear fuel from the core and removal from the reactor of the internal
housing devices in order to control the condition of the internal sur-
faces of the reactor housing and the internal housing devices.

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On the basis of their design features the water-cooled reactors require a full stop for refueling in the core.

The fuel (nearly 40 tons of appropriate enrichment for each type of reactor) that has been loaded into the reactor is adequate for the operation of the power unit at capacity for 300 to 350 24-hour periods. After using up this time and exhausting the supply of reactivity it is necessary to refuel. On a reactor that has been stopped and cooled to a temperature of 40 to 70 degrees C a depressurization is performed by removing the cover and then using a reloading machine according to special programs done on a computer the refueling operations are carried out. The fuel assemblies which have the least remaining amount of ²³⁵U isotope in fuel elements, or the greatest burning of ²³⁵U, are unloaded from the reactor and fresh fuel is loaded into it. During the refueling operation in accordance with an estimate approximately one third of the fuel assemblies is reloaded. This is enough fuel for the reactor until the next refueling in a year. In this manner, each fuel assembly works in the reactor over a three-year period.

The refueling operation is a rather complicated and important operation; mistakes cannot be permitted to happen. For this reason the refueling program is compiled on a timely basis; the correctness of executing this program is monitored by personnel from the physics laboratory.

Planned work on equipment repair of the first circuit and monitoring of the metal of the equipment and pipelines are carried out during the refueling operation. To perform these tasks within the necessary time periods long before the power unit is stopped for refueling a network schedule is compiled, which reflects all work to be done while the unit is down. The schedule also displays the time periods and labor expenditures required for the work. Measures for the organizational and technical support of preparing for the refueling are also specified in the network schedule.

Very serious attention is given to compiling the documentation for preparing for refueling at the Novovoronezh AES. The correctness of the documents that are drawn up and the conduct of the preparations for them are a sure guarantee for the qualitative execution of the refueling and repair work within the shortest possible time periods.

The first shutdown of the reactor of the first power unit of the Novovoronezh AES for refueling and repair was performed from 29 October through 12 December 1965. The shutdown lasted 43 days.

The experience gained during the first refueling was carefully analyzed and used when preparing for subsequent shutdowns. The second refueling of the first power unit was done in 1966; it took 41 days. The fourth refueling was in 1968 and it took 29 days.

At the Novovoronezh AES a great deal of experience has been gained in refueling. One would expect that a refueling could be done in 20 to 25 days, but in connection with the one-time execution of planned repair work and metal examination, refueling takes from 25 to 30 days.

A 30-day period has been accepted as the standard shutdown for refueling water-cooled reactor power units.

The designed depth of burning the unloaded, expended fuel in all reactors has been exceeded through the adoption of measures to improve the use of fuel.

Table 4 demonstrates that the designed average depth of burning the unloaded fuel is equal to 12.85 kg of poison /shlak/ per ton of uranium for the VVER-210; 27.8 kg for the VVER-365; and 28.3 kg of poison per ton of uranium for the VVER-440. This depth has now been exceeded for all power units. In the reactor of the first power unit this has been achieved by using TVS /fuel assembly/ with a 3 percent enrichment (up to 30 assemblies), with a designed enrichment of the loaded fuel at 2 percent. In the reactor of the second power unit an increase in the burning of the unloaded fuel was provided basically by adopting a TVS with a 3 percent enrichment without absorption elements [pel]. The actual burning of the unloaded fuel was able to exceed the designed burning for the VVER-440 reactor of the third power unit by switching this reactor to a fuel feed of a standard enrichment of 2.4 to 3.6 percent for the VVER-440 reactor. The use in the fuel sections of the SUZ /system for controlling and protecting the reactor/ TVS assemblies with a 2.4 percent enrichment in a mode of two refuelings per operating period of these assemblies has had a definite influence on burning.

The systematic use of the regime for extending the operating period was also brought about to a certain extent by an overall increase in the burning of the unloaded fuel for all of the AES's reactors. The maximum depth of the fuel burning in individual unloaded fuel assemblies equalled for the first power unit 31 kg of poison per ton of uranium (initial enrichment was 2 percent); for the second power unit this figure was 48.1 kg of poison per ton of uranium (initial enrichment was 3 percent); and for the third power unit the figure was 50.4 kg of poison per ton of uranium (initial enrichment was 3.3 percent with absorption elements [pel]).

To maintain an adequately low radioactivity of the cooling agent of the first circuit and the timely discovery and rejection of assemblies with non-hermetically sealed fuel elements [tvel] at AES's with water-cooled reactors, special control methods are used, which are based upon the registration of the availability of fission products of the nuclear fuel in the cooling agent of the first circuit.

On a working reactor the condition of the fuel element jackets is evaluated using a radiochemical analysis of the cooling agent and additionally by looped control systems for the delayed neutrons. The purpose of the radiochemical analysis is to evaluate the content of radionuclides - iodide, barium, strontium, xenon, krypton, cesium and neptunium - in the water of the first circuit. To separate the nuclides from the samples of the cooling agent use is made of radiochemical methods for separating into tissue sorbents, partition chromatography and extraction methods.

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Table 4: Description of reactor fuel loads at the Novovoronezh AES for the combustion of nuclear fuel

Year of initial start	Length of load operation, in 24-hour days				Average depth of combustion in the unloaded fuel, MW 24-hour period/ tons of uranium				Maximum depth of combustion of individual unloaded assemblies, MW 24-hour period/ tons of uranium			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1964	222	-	-	-	4.8	-	-	-	6.8	-	-	-
1965	217	-	-	-	10.4	-	-	-	13.8	-	-	-
1966	190	-	-	-	11.4	-	-	-	15.9	-	-	-
1967	248	-	-	-	13.0	-	-	-	19.0	-	-	-
1968	308	-	-	-	16.1	-	-	-	25.8	-	-	-
1969	189	143	-	-	12.6	4.5	-	-	31.0	5.5	-	-
1970	-	43	-	-	-	6.2	-	-	-	9.0	-	-
1971	281	316	280	-	15.2	19.2	9.3	-	23.0	21.7	12.0	-
1972	-	317	-	348	-	27.5	-	12.2	-	33.6	-	14.8
1973	248	311	320	-	13.7	25.6	19.4	-	18.8	36.8	25.9	-
1974	319	302	197	346	17.2	27.9	24.9	23.7	26.7	41.4	30.5	25.5
1975	347	310	350	329	16.8	26.9	26.8	30.1	29.3	40.6	39.6	34.4
1976	318	318	301	296	18.1	29.2	30.4	29.4	27.0	48.1	41.4	34.6
1977	270	311	339	334	17.7	28.2	30.9	28.8	29.9	32.5	50.4	35.2
1978	301	377	339	293	17.2	27.9	30.0	29.5	28.7	33.4	36.4	34.3

COMMENT: I - IV are the numbers of the power units.

A method for controlling the isotope composition of the cooling agent without taking samples has been adopted on power units III and IV at the Novovoronezh AES. Using a gamma-spectrometer based on a semiconductor detector a direct measurement is accomplished in the pipeline on the mixed action bypass-filter of the water cleaning unit of the first circuit.

The continuous monitoring of the condition of the fuel element jackets on an operating reactor is accomplished by looped systems, which make it possible to monitor the dynamics of the development of the fuel element sealing process and to issue recommendations on the periodicity of the radiochemical analysis of the cooling agent.

During the reloading of reactors extensive use is made of a method, which is based upon the miscount of the activity of the gas sample, which was selected from the hermetically sealed can with the TVS being tested. This is the so-called dry method. Preliminary experiments have been conducted on determining the speed of the TVS warm-up in a dry can for determining the amount of time that the TVS can safely be in the air. The experiment demonstrated that the amount of time is 10 minutes that the TVS can be in the air. The sensitivity of the method is sufficiently high. The dry method, as a rule, identifies all TVS's with fuel elements that are not hermetically sealed.

The dry method is relatively simple and does not require complicated equipment; it makes it possible to combine operations for monitoring the fuel element jackets with the technological operations for reloading the core of a reactor, thereby reducing the time required for reloading fuel.

To precisely determine the extent to which the fuel element jackets are not hermetically sealed in the TVS, which was divulged using the dry method, the activity of the iodide in the water samples are determined when steeping the TVS in water. In other words, use is made of the so-called wet method.

Experience in monitoring the hermetic seal of the fuel element jackets of the TVS during the reloadings of the nuclear fuel in the reactors of the power units and in the radiochemical composition of the cooling agent of the first circuits and the results of TVS research in the protective chamber attest to the high reliability of the TVS's that are used at the Novovoronezh AES.

At present the monitoring of the hermetic seal of the fuel element jackets in a reactor that has been shut down is not conducted during each reloading; the need to monitor is evaluated according to the results of monitoring the radiochemical composition of the cooling agent and according to data of the system for monitoring the hermetic seal of the fuel element jackets for delayed neutrons during the operation of the reactor at rated capacity.

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Controlling the Fuel Cycle

During the operation of the reactors of the Novovoronezh AES a great deal of attention is devoted to questions having to do with optimizing the use of nuclear fuel. Based upon the planned amount of maintenance and reloading work and also taking into consideration the power unit shutdowns for current repair work the planned utilization coefficient is determined for the established rated capacity of each power unit; and the amount of time needed for the operation of the fuel loads of the reactors is evaluated; and the amount of fuel to be ordered is precisely determined.

Difficulties in planning the annual schedule for loading the power units are to be found in the fact that the actual utilization coefficient of the established rated capacity can differ greatly from the estimated as the result of unforeseen deviations from the planned work regime. This leads to a lack of precision in planning the moment when the supply of radioactivity is exhausted for combustion at a nominal thermal rated capacity of the reactor. The error can reach 10 to 15 percent when determining the utilization coefficient of the established rated capacity, which in turn leads to an error in selecting the duration of the operating period up to 30 24-hour periods. If the duration of the operating period is estimated with an error of up to 6 percent, the error amounts to 20 24-hour periods.

All of this attests to the need of controlling the fuel cycle of the reactors, which makes it possible to minimize the consequences of these errors.

The fuel loads of the VVER-type reactors are selected using a set of programs; moreover, several variants of the cartograms of the configurations of the reactor core are estimated. The estimated duration of the operating period is ensured by loading the determined amount of fuel.

At the Novovoronezh AES to increase the efficiency of using fuel several measures are taken. In particular, in the process of operating the AES they use a regime for extending the operating period. The feasibility of extending the operating period is connected with the freeing and use of additional reactivity using temperature and capacity effects. To do this it is necessary to reduce the temperature of the first and second circuits and also to reduce the pressure of the steam as it leaves the steam generators.

Extending the operating period makes it possible to increase the average depth of fuel combustion and to somewhat reduce the fuel component of the cost of producing electric power. In turn, reducing the load in the power unit results in some increase in the capital component of the cost of producing electric power and reducing the usefulness of the power unit.

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For AES's, which have several power units, the possibility of their working in an extended operating period mode makes it possible to more freely establish a time for commencing the fuel reloading, while making a comparison with the conditions that have evolved within the power systems and with the possibilities of performing maintenance.

Specialists from the scientific-research department of the Novovoronezh AES have devised a methodology for evaluating the optimal work time of the power units with VVER-210, VVER-365, and VVER-440 reactors at capacity and temperature effects. The power units in such a regime were used repeatedly. From the experience of the work of the power units in a capacity effect in a regime of the natural reduction of the parameters of the first and second circuits with the turbine throttles fully open (without an emergency supply of reactivity on the reactor's regulating organs) and in connection with the by-stage reduction of the reactor's thermal capacity (with an emergency supply of reactivity on the reactor's regulating organs) it follows that the maximum output of electric power is achieved during the natural reduction of the parameters of the power units.

The regime for extending the operating period is especially expedient when it is necessary to carry out capital repairs on one of the turbines of the power unit, for which a longer stand-down is required than for reloading the power unit. In this case the turbine is removed for capital repair after exhausting the supply of reactivity for combustion; and the power unit is stopped for reloading with an estimate that results in both turbounits being ready for operation by the end of its reloading. Our experience shows that in this case we achieve the highest indicators for fuel use.

The regime for extending the operating period in actual conditions is an important tool for raising the flexibility of planning the work and improving the technical-economic work indicators of the power unit having VVER-type reactors.

In Table 5 we see that when power unit No 2 at the Novovoronezh AES is operating in the extended operating period mode for no more than 40 24-hour periods the utilization coefficient of the rated capacity is not reduced below 80 percent, which corresponds to the normative coefficient of rated capacity for an AES. The work of the power unit in the extended operating period mode with an average coefficient of rated capacity below 80 percent is inexpedient.

The time of work in capacity and temperature effects for each power unit can be changed depending upon the condition of their technical-economic characteristics, which is connected basically with the time of year and is determined by an estimate of the technical-economic indicators of this mode.

The mode for changing capacity during the operation of the reactor in capacity and temperature effects is of particular interest, when during the hours of the morning and evening load maximum the rated capacity is raised to 100 percent by increasing the reactivity from the

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Table 5: Description of the work of power unit No 2 of the Novovoronezh AES in the extended operating period mode

Indicator	Point of reference	Operating period number				
		III	IV	V	VI	VII
Calendar time of power unit operation	24-hrs	76	60	34	43	32
Effective work time	24-hrs	50	47	30	37	28
Additional output of electricity	millions of KW/hrs	418	405	254	314	249
Coefficient of utilization of rated capacity	percent	63	77	85	83	89
Average electrical capacity	MW	229	282	341	304	324
Initial and final electrical capacity	MW	<u>278</u> 191	<u>342</u> 219	<u>352</u> 246	<u>362</u> 248	<u>380</u> 262
Average value of gross efficiency of power unit	percent	26.6	26.9	26.9	26.7	28.0
Average percentage of electric power consumption for personal needs	percent	7.36	6.52	6.12	5.8	5.33

reduction of the poisoning of the reactor during its operation at the reduced capacity during the day-time and night-time dips of loads in the power system. Such a mode was tested on power unit No 2 in the spring of 1973. At this mode the output of electric power is less, but a higher capacity is ensured during the peak consumption hours from the power system than at a stable capacity.

In Table 6 we see the duration of the operation of the reactors in a capacity effect in the years 1972 through 1976. Within just five years 4.7 billion KW/hrs of electricity was produced when operating in a capacity effect; during this same time period 42.64 billion KW/hrs of electricity were generated altogether.

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Table 6: Duration of the operation of reactors in a capacity effect during the years 1972 through 1976

Power unit	Operating period	Year	Duration of operation		Output of electricity in capacity effect, KW/hrs	Reduction in capacity, in MW/24-hrs
			Eff. 24/hrs	24/hrs		
I	IX	1975	15.2	17	76.4	2.0
	X	1976	42.8	56	206.8	2.0
II	III	1972	49.6	76	417.8	2.5
	IV	1973	47.5	60	405.3	2.5
	V	1974	29.7	34	253.6	2.1
	VI	1975	37.1	43	314.5	2.4
	VII	1976	28.0	32	249.1	2.4
III	I	1973	30.6	40	286.9	3.3
	II	1974	60.9	80.5	584	3.0
	IV	1976	53.9	69	495.3	3.2
IV	I	1974	47.1	60	456.9	3.0
	II	1975	49.8	66	477.3	3.4
	III	1976	32.7	46	309.9	3.3
TOTAL					4,700.0	

Thus, when working in a capacity effect more than 11 percent of the electric power was produced, which is a considerable bonus.

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ELECTRIC POWER

USE OF FLOATING ATOMIC POWER STATIONS IN NORTHERN REGIONS

Moscow ATOMNAYA ENERGIYA in Russian Vol 51, No 2, Aug 81
(manuscript received 26 Feb 81) pp 83-87

[Article by A. I. Golovin, V. M. Abramov, K. I. Kovalenko, G. V. Merzlikin, Yu. A. Sergeyev, G. A. Sosonkov, A. P. Suvorov, P. V. Sukhoruchenkov, V. M. Shmakov and A. T. Shmarev]

[Text] The operation of drilling rigs used in deep exploratory drilling for oil and gas is now supported, with one slight exception, by diesel drive and boiler plants operating on fossil fuel. However, the use of electric motors is more efficient for these purposes.

The advantages of electrifying exploratory drilling make it possible to reduce the length of individual production operations and to increase the commercial rate of drilling wells by an average of 15 percent because of this, to reduce the number of workers involved in drilling by approximately 12 persons in each brigade and the mass of basic equipment by 12-14 percent, to simplify installation and construction and to reduce the excavation area occupied by construction of wells up to 10 percent. The advantage of this method is also the fact that the working conditions and everyday life of the drilling brigades are improved with complex electrification and the possibility of the soil and reservoirs being contaminated by petroleum products is sharply reduced.

Many promising areas for prospecting for oil, gas and other minerals in the Arctic are located in regions with an extensively developed system of large and small rivers or in other difficultly accessible places. Since transport communications is difficult on these sections, the use of floating AES [Atomic power stations] can solve many problems of energy supply, organization and management of geological prospecting work, especially operations in deep exploratory drilling for oil and gas related to considerable expenditures of labor, energy and materials.

The use of floating AES in deep exploratory drilling for oil and gas also opens up the opportunity to carry out complex electrification and thus to significantly increase the overall efficiency of operations. Development of floating AES with output of 6,000 kW (Figure 1) and corresponding engineering and economic investigations were carried out in this regard that showed the real possibility of developing these AES and the effectiveness of using them.

The development and operation of floating AES, designed to provide production and service facilities of geological prospecting organizations and drilling rigs with electric power and heat, have the following characteristics:

size restrictions, primarily in draft, related to the need to pass through shallow rivers, bays or gulfs;

prolonged operation under conditions of great remoteness from industrial centers and repair bases and the rigid requirements on reliability and autonomy caused by this;

irregular loading regime typical for drilling wells, that places higher requirements on the operation of the energy unit of a floating AES under portable conditions.

It was feasible ABV-1.5 water-cooled boiling-water reactors on floating AES with regard to the size requirements and some other concepts [1]. Installation of two independently operating nuclear power units (YaEU) was provided on these AES. This solution is the best to ensure the required reliability and uninterrupted generation of electric power. The output of each YaEU is 3,000 kW (of electricity), which ensures that the users will be supplied with total peak power of 5,000-6,000 kW.

ABV type reactors differ from ordinary VVER [Water-cooled power reactor] by integral configuration, i.e., by location of the core and steam generator in the same strong vessel. Moreover, natural circulation of the coolant in the first and second circuits of the nuclear steam-producing unit (YaPPU), self-regulation of reactor power by negative temperature coefficient of reactivity and production of saturated steam with variable parameters, steam-generator built into the reactor vessel which consists of field pipes separated into sections and that permit repair (plugging the pipes) without unsealing the first circuit are typical for them. All these solutions and also some propositions adopted in development of YaPPU of type ABV contribute to special operating reliability and simplicity of maintenance.

Comparison of the integrated and polyunit configurations of YaPPU from the viewpoint of economic indicators with output of 50 MW (electricity) and below show the feasibility of using integrated configurations [2]. YaPPU of type ABV with unit output from 12 to 65 MW (heat) were developed in this regard [3]. An ABV-1.5 YaPPU with output of 14.5 MW (heat) was used in the project of the block transportable atomic TETs Sever-2, designed to supply power to remote and difficultly accessible regions [1, 3]. Subsequent investigations showed that a VVER with integrated configuration and natural coolant circulation of considerably greater unit output (up to 200 MW (electricity) and above) [4] can be developed for the YaPPU, used in stationary AES.

The developments confirmed that integrated YaPPU that produce saturated steam can be made with natural coolant circulation in the first and second circuits up to output of at least 12 MW (electricity) for floating AES, which are proposed for operation on internal reservoirs.

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Thus, an integrated configuration, natural coolant circulation and self-regulation that ensure high operational reliability determined selection of the ABV-1.5 YaPPU for use on the floating AES Sever, designed for autonomous operation in remote Arctic regions. An extensive complex of calculation and experimental investigations that confirmed the outlined conclusions and values of parameters of the ABV-1.5 YaPPU in the project of the AES Sever has now been carried out by specialized organizations. A core with cluster reactivity compensation system has also been developed which permits an increase of ABV-1.5. output to 18 MW (heat) and thus to ensure that electric output of 3,000 kW is produced from each of two energy units of the floating AES.

The main steam generating unit of the ABV-1.5 YaPPU consists of four main parts (Figure 2): a housing, cover with steam generator sections, radiation shielding of the vessel with core basket and recharging cover with SUZ drives.

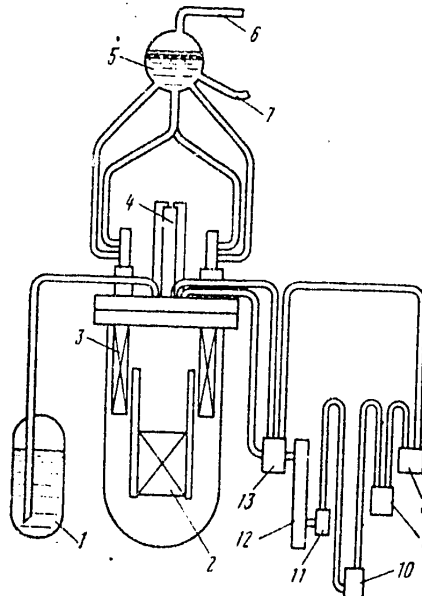


Figure 2. Diagram of Steam Generating Unit of ABV-1.5: 1--expansion tank; 2--core; 3--steam generator; 4--SUZ; 5--separator; 6--steam to turbine; 7--feedwater inlet; 8--cooling unit of decontamination and cooling system; 9--pump; 10--electromagnetic filter; 11--ion-exchange filter; 12--cermet filter; 13--regenerative heat exchanger

Moreover, the ABV-1.5 YaPPU contains:

a steam expansion tank equipped with electric heaters and designed to maintain required pressure (72 absolute atmospheres = 7.26 MPa) in the first circuit over the entire range of coolant temperature variation from normal to operating (approximately 240°C);

a coolant decontamination system for the first circuit that includes mechanical, electromagnetic and ion-exchange filters;

scheduled, emergency and repair cooling systems;

a separator drum with pipeline system that link it to the steam generator section and that cuts off the natural coolant circulation channel of the second circuit;

normal and emergency delivery system of the first circuit, storage of spent fuel assemblies, a recharging machine and miscellaneous auxiliary systems and devices that ensure operation of the YaPPU during prolonged autonomous operation of a floating AES.

A distance of 1,000 mm is provided between the core and the lower end of the steam generator sections to restrict activation of the second circuit. All leads from the reactor are made without a cover. Based on the condition of locating two ABV-1.5 YaPPU, two turbogenerators, starting diesel generators and miscellaneous equipment on board a floating AES, the main dimensions of the AES Sever were taken as follows (Figure 3).

Overall length	83.6 meters
Width	21.0 meters
Depth to main deck	3.7 meters
Transport draft when travelling along a river	1.94 meters
Draft during operation	3.03 meters

The floating AES Sever is not self-propelled. It is towed to the operating points and is installed in natural dams or specially erected shore cuts protected from the effect of water and ice and also partially from the effect of wind.

Taking established practice and the prospects for development of prospecting methods into account, we proceeded from conditions of energy support for deep exploratory drilling for oil and gas when using two or three drilling rigs operating simultaneously, separated up to 25-30 km from the AES and supplied with electric power by means of LEP [Overhead power transmission line] or cables designed for a voltage of 6 and 35 kV when selecting the output of these AES. It was shown that the required output of a floating AES should comprise approximately 6,000 kW when using drilling rigs for wells up to 5 km deep. This output will also be adequate for supplying power to housing and production bases when prospecting for solid minerals.

After prospecting or exploratory wells have been drilled in a given region or when further drilling is carried out using mobile gas turbine electric power stations operating on the fuel found (gas, condensate or oil), the AES Sever can be moved to new regions.

The necessary complex of machinery and devices that ensure fulfillment of adjustment (preventive maintenance, repair and so on) operations, improving the

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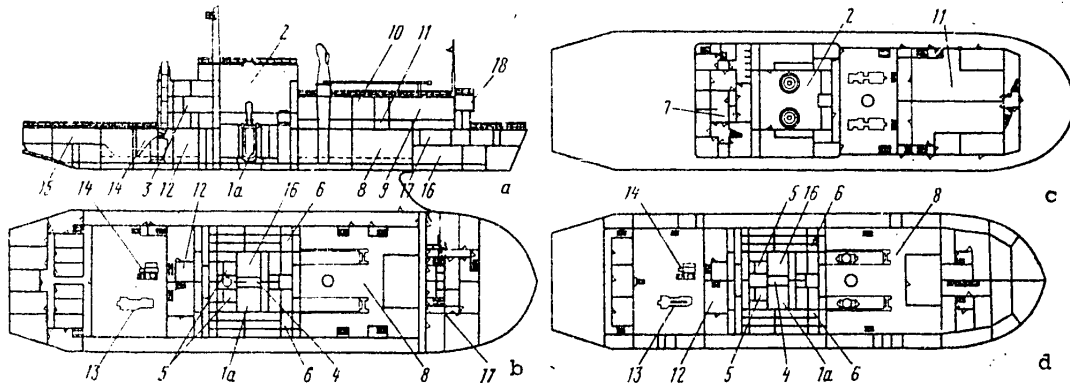


Figure 3. Arrangement of Equipment on Floating AES Sever: a--longitudinal profile; b--hold; c--upper deck; d--main deck; 1a--right YaPPU; 1b--left YaPPU; 2--equipment room (room for regulating operations); 3--auxiliary room of YaPPU; 4--spent fuel storage; 5 and 6--apparatus for concentration and hardening of liquid wastes of high and low activity, respectively; 7--sanitation control point; 8--turbogenerator section; 9--control station; 10--room for electric distributing devices; 11--cable room; 12--room for waste tank and air lift pumps; 13--auxiliary diesel electric station section; 14--auxiliary boiler section; 15--workshops and stores; 16--laboratories; 17--service-housekeeping rooms; 18--observation station

recharging of spent TVS [Fuel assembly] from the reactor to the storage depot for cooling and subsequent transfer for reprocessing or burial, is provided onboard a floating AES with regard to the prolonged period of autonomous operation (no less than 810 years with a possibility of redeployment every 2-3 years) under the complex natural-climatic and economic conditions of the Arctic. The storage depot is designed to receive three sets of spent TVS (two scheduled and one emergency). The recharging machine, gantry and external crane and different technical accessories ensure reception and loading of fresh fuel and unloading of spent TVS and solid radioactive wastes.

The provided apparatus for concentration and burial of liquid radioactive wastes are designed for total reprocessing and concentration of all high- and low-active wastes to a dry state. They can be stored at the AES in the form of a dry residue and then removed from it as part of solid radioactive wastes to central burial locations.

Complex automation of the control and monitoring systems of YaPPU operation and also the remaining systems and machinery is provided on the floating AES Sever. It is suggested that 42 persons will service this AES. A total of five duty shifts of watch personnel--four shifts of workers and one reserve--is provided. Besides the duty shift, the daytime shift includes supervisory and repair personnel.

As is known, a considerable part of the mass of any atomic-powered vessel is the YaEU [Atomic power plant]. The mass of the latter is determined mainly by the mass of the biological shielding, the presence of which leads to an appreciable increase of displacement and consequently to an increase of the draft of the vessel. For example, the draft of the floating AES Sturgess (one water-cooled boiling-water reactor with output of 10 MW (electricity)) constructed in the United States is equal to 4.5 meters [5]. It is obvious that this AES can be used on a limited number of reservoirs, which sharply reduces the possibility of using it, especially for the needs of geological prospecting.

Therefore, the principal difference of the functions of the YaEU on an atomic-powered vessel, where it is the propulsion plant, and on a floating AES, where the YaEU operates only when the station begins operation at a site, was taken into account when developing the AES Sever. This circumstance permits one to allocate two main functions of biological shielding of a floating AES to supporting the normal radiation situation: during operation of one or both reactors at a required location and with shutdown and cooled-down reactors during redeployment of the station to a new site.

According to this, the biological shielding of the floating AES Sever is divided into two parts: an inherent accessory of the YaPPU transported during redeployment as part of the station and removed from the AES prior to its redeployment and newly installed after arrival at the new operation site.

Transportable shielding provides radiation safety during redeployment of a floating AES, i.e., with shut-down reactors, while total shielding supports the radiation situation in rooms and in external surroundings that meets the radiation safety regulations (NRB-76) with one or two operating reactors. With one operating reactor, fuel recharging and repair operations on a shut-down reactor are possible.

The transportable part of the shielding is designed with regard to the requirement of redeployment of a floating AES every 40-45 days after the reactors have been shut down. This time is considered as that required to prepare the station for movement. Transportable shielding is designed to attenuate the residual radiation of the fuel assemblies in the reactor and during storage of spent TVS and also activation radiation of the structures and equipment of the YaPPU. The active equipment of the YaPPU is located in the vessel of the floating AES as compactly as possible and with regard to its use as biological shielding components to reduce to a maximum the mass of the transportable shielding. The radioactive equipment--reactors and storage of spent TVS located between them--are shielded by a layer of lead and are located in a tank with boric acid water. This shielding also provides access to the equipment and fittings of the first circuit for inspection and repair when the reactors are shut down. The thickness of the lead layer is shaped as a function of the direction, intensity and energy spectrum of the radiation and comprises 3-7 cm. The thickness of the water layer varies from 85 to 170 cm. The total mass of the transportable shielding is approximately 200 tons. The less active equipment of the YaPPU (expansion tanks, cooling system and so on) is used, as was mentioned, as shielding components of more active equipment.

The second part of the shielding removed prior to redeployment is the main component that ensures attenuation of the radiation of operating reactors. When it is

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removed, the draft of the floating AES comprises approximately 2 meters, which permits it to travel over many internal waterways of the northern and northeastern regions of the USSR, especially during the period of high water levels, i.e., during floods.

According to the foregoing, the reactors are installed in special shafts located in tanks of the transportable shielding, while the miscellaneous active equipment of the YaPPU (expansion tanks, decontamination system for the first circuit, ion-exchange filters, evaporation apparatus of radioactive wastes and bubbling tank) are configured into blocks and located in shafts located in the main part of the shielding. The shafts are covered above by protective plugs. Top attachment is provided for all the equipment to improve repairability.

The SUZ drives are led directly to the reactor compartment and are covered with a special hermetically sealing cap. The volume of the cap is included in the hermetically sealed space of unserviced rooms (shafts) of the YaPPU and prevents active steam from entering the part of the reactor compartment being serviced during emergencies when the pipelines of the first circuit are unsealed.

Deaerators are located on the upper deck to provide the required pressure head to the feed pumps. All the remaining equipment is arranged in groups by designation (see Figure 3). This arrangement permits a considerable reduction of the length of the pipelines and improvement of operating conditions.

Workshops and laboratories and also an auxiliary diesel electric station with output of 400 kW, emergency electric power station with output of 100 kW and an auxiliary boiler plant operating on diesel fuel and used during distillations, during installation of the station at a new site and during preparation of it for redeployment, are provided on a floating AES. Housing quarters for the crew on-board during towing are located on the floating AES. Housing is not provided for the operating personnel, based on the experience of developing the floating electric power station Severnoye siyaniye.

The advantages of electrified systems for exploratory drilling indicated above are manifested regardless of the types of fuel used by autonomous energy sources. Additional, very important advantages of electrified exploratory drilling systems--a considerable reduction of the total volumes of work in transportation of fuel and other goods, construction of production bases for expeditions and parties, temporary housing villages and branch repair-machine bases and as a result a considerable reduction of the need for a work force--appear when floating AES are used. As a result one can expect a reduction in the cost of drilling exploratory wells for oil and gas in northern regions with the optimum operating conditions of floating AES by approximately 20 percent compared to the diesel version and one can expect an increase of labor productivity by 25-30 percent. Floating AES can satisfy the most diverse conditions of geological prospecting work.

Thus, the economic effectiveness, an increase of labor productivity, improvement of environmental protection, operational autonomy and high reliability permit one to conclude that introduction of floating low-power atomic power stations into geological prospecting work is feasible.

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UDC 621.311.42.027.3-182.3(571.651)

MOBILE TRANSFORMERS MOVED BY SLED

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, 1981 pp 70-71

[Article by A. G. Kucher, engineer, Magadanenergo: "Sled-Mounted Transformer Substations"]

[Text] Under the conditions prevailing in the Far North the overwhelming majority of 35 kV substations have transformer capacities up to 6300 kV·A. As a rule, customer connections are few--three to five. But mining industry customers characteristically employ mobile electric transducers. As a result we see 6 kV lines extending farther and farther from substations, and it eventually becomes necessary to put in another substation at a new location, which involves difficulties in planning and design, the provision of equipment and the construction of a specifically zero cycle.

The construction process usually breaks up the surface layer of the soil, and the permafrost thaws despite the gravel spread over the area around the ORU [outdoor distribution system] after the completion of construction operations. All strip foundations and concrete slabs consequently begin to "float" and to sag and buckle; conditions in Chukotka therefore require the construction of deep pile-supported foundations and the expenditure of scarce construction materials and metal in order to preserve the substation's zero cycle.

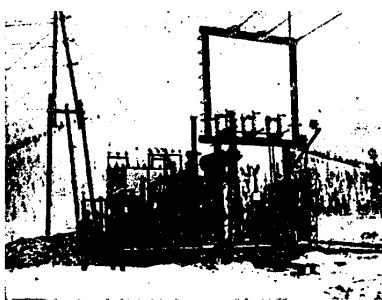


Figure 1. General view of mobile sled-mounted 35/6 kV substation with 1800 kV·A transformer (version without VM-35, on line-transformer unit).

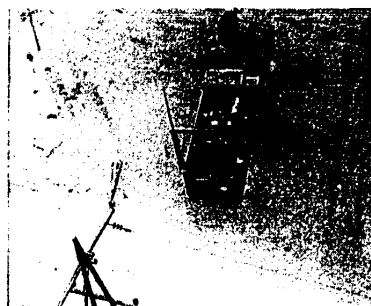


Figure 2. Helicopter view of mobile sled-mounted 35/6 kV substation with 2500 kV A transformer (version with VM-35).

If the substation has to be moved to a new location the equipment, switching devices, busbars and metal construction can be re-used; but all the foundations have to be re-built and the old ones left behind.

The northern electric-power systems of Magadanenergo decided to conduct an experiment. Together with the Bilibinskiy ore-dressing combine, the network production organization designed and built a mobile sled-mounted 35/6 kV substation (Figures 1 and 2) to supply electric power to mine sites during major repairs of permanent step-down substations. In Chukotka the equipment in outside installations can be repaired or painted only in the summer, since the climatic conditions in the Far North do not permit this in winter. The short summers, however, are periods of intensive operation for mining-industry complexes, and they cannot permit substations to be shut down and electric power to be turned off. Switching this function to a mobile substation has made it possible to shut a permanent facility down at a favorable time and perform repairs with equipment completely de-energized.

Since northern power-system specialists have not gone in for simplification in designing and equipping the mobile substation with devices and units for switching, automatic operation, protection and metering, it has proved an entirely reliable source of electric power in no way inferior to a permanent facility. The Bilibinskiy ore-dressing combine very quickly began to employ a version of the mobile substation as a main power source. The only component requiring construction in installation of the mobile substation is the ground circuit, which under permafrost conditions, as a rule, takes the form of a deep shaft sunk by a special method employed by VNII-1 Mintsvetmet [All-Union Scientific Research Institute-1 of the USSR Ministry of Nonferrous Metallurgy].

The Bilibinskiy ore-dressing combine has begun to fabricate mobile substations in place of permanent facilities at the sites of new mines, and, without any decrease in reliability, this has made it possible not only substantially to accelerate the installation of new power-supply systems, but, by realizing a saving of roughly 40,000 rubles per single-transformer substation, to do it more cheaply as well.

If it becomes necessary, the mobile substation is easily transported over winter roads or over the tundra by one or two bulldozers. The substation receiving gantry is then folded into a travelling position and does not interfere with movement. The substation may be put into operation in a new location within minimal periods of time provided a ground circuit is ready.

Advantages of the sled-mounted substation would also include the fact that the surface soil cover under the sled remains unbroken, which insures preservation of the permafrost regime and a stable horizontal position for the substation platform.

The minimum capacity of the transformer mounted on the mobile substation is 35/6 kV, 6300 kV·A.

If it becomes necessary to increase the number of outgoing lines, external distribution boxes may be mounted on supports attached to the sled platform.

CONCLUSION

To reduce the cost of supplying electric power in the Far North, consumers with unstable power transducer locations should be provided with mobile, sled-mounted transformer substations.

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